

Version with Markings to Show Changes Made

IN THE CLAIMS:

1        22. (Twice Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having a plurality of converter circuits for operating into a  
4 common load, comprising:

5        a plurality of buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10        a plurality of pulse width modulators driven by a common  
11 oscillator in an interleaved manner, each pulse width modulator  
12 controlling [power switching devices of] one of the plurality of  
13 buck converter circuits, whereby the operation of the buck  
14 converter circuits is interleaved;

15        a feedback circuit responsive to a voltage across the common  
16 output [load];

17        a voltage control circuit [for] controlling the plurality of  
18 pulse width modulators responsive to the feedback circuit and a  
19 commanded output voltage; and

20        a current balance control circuit responsive to the  
21 difference in current in the plurality of interleaved buck

*C1  
Contd*

22    converter circuits and [for] controlling the pulse width  
23    modulators to balance the current in the plurality of interleaved  
24    buck converter circuits;  
25       the plurality of pulse width modulators and the control  
26    circuits being in a single integrated circuit.

*C2  
Sub  
Sect*

1       24. (Twice Amended) The DC to DC [switching circuit]  
2    converter of claim 22 further comprised of an integrator having  
3    an output responsive to the integral of an error signal, the  
4    error signal being responsive to the voltage across the common  
5    load and a desired voltage, the control circuits also being  
6    responsive to the output of the integrator.

1       25. (Amended) The DC to DC [switching circuit] converter  
2    of claim 24 wherein a time constant of the integrator is  
3    adjustable by the selection of at least one component external to  
4    the integrated circuit.

*C3*

1       26. (Amended) The DC to DC [switching circuit] converter  
2    of claim 24 further comprised of a differentiator having an  
3    output responsive to the rate of change of the voltage across the  
4    common load, the control circuits also being responsive to the  
5    output of differentiator.

1        27. (Amended) The DC to DC [switching circuit] converter  
2 of claim 26 wherein the time constant of the differentiator is  
3 adjustable by the selection of at least one component external to  
4 the integrated circuit.

1        28. (Amended) The DC to DC [switching circuit] converter  
2 of claim 22 wherein the control circuits are also responsive to  
3 rapid decreases in the voltage across the common load to turn on  
4 the plurality of buck converter circuits independent of the phase  
5 of the plurality of pulse width modulators.

1        29. (Amended) The DC to DC [switching circuit] converter  
2 of claim 28 wherein the control circuits are also responsive to  
3 rapid increases in the voltage across the common load to turn off  
4 the plurality of buck converter circuits independent of the phase  
5 of the plurality of pulse width modulators.

1        30. (Amended) The DC to DC [switching circuit] converter  
2 of claim 22, wherein the plurality of pulse width modulators  
3 consist of a pair of pulse width modulators.

1        31. (Amended) The DC to DC [switching circuit] converter  
2 of claim 22 wherein the feedback circuit is in the single  
3 integrated circuit.

*Subj A*

1        32. (Twice Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having a plurality of converter circuits operating into a common  
4 load, comprising:

5            a plurality of buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10          a plurality of pulse width modulators each controlling  
11 [power switching devices of] one of the plurality of buck  
12 converter circuits, the operation of the pulse width modulators  
13 and the buck converter circuits being interleaved;

14          a feedback circuit responsive to a voltage across the common  
15 load;

16          control circuits responsive to the feedback circuit and a  
17 commanded output voltage to control a nominal duty cycle of the  
18 plurality of buck converter circuits, the control circuits also  
19 being responsive to the difference in current in the plurality of  
20 interleaved buck converter circuits to adjust [adjusting] a  
21 relative duty cycle of the plurality of buck converter circuits  
22 to balance the current in the buck converter circuits;  
23          the plurality of pulse width modulators and the control  
24 circuits being in a single integrated circuit.

*AS*

1        34. (Twice Amended) The DC to DC [switching circuit]  
2        converter of claim 32 wherein the control circuits control the  
3        plurality of pulse width modulators.

*CG*

1        35. (Amended) The DC to DC [switching circuit] converter  
2        of claim 32 further comprising[:] an integrator having an output  
3        responsive to the integral of an error signal, the error signal  
4        being responsive to the voltage across the common load and a  
5        desired voltage.

*AS*

1        36. (Twice Amended) The DC to DC [switching circuit]  
2        converter of claim 35, wherein the control circuits are also  
3        responsive to the output of the integrator.

*CG*

1        37. (Amended) The DC to DC [switching circuit] converter  
2        of claim 35 wherein a time constant of the integrator is  
3        adjustable by the selection of at least one component external to  
4        the integrated circuit.

*CG*

1        38. (Amended) The DC to DC [switching circuit] converter  
2        of claim 35 further comprising a differentiator having an output  
3        responsive to a rate of change of the voltage across the common  
4        load, the control circuits also being responsive to the output of  
5        differentiator.

1        39. (Amended) The DC to DC [switching circuit] converter  
2 of claim 38 wherein a time constant of the differentiator is  
3 adjustable by the selection of at least one component external to  
4 the integrated circuit.

1        40. (Amended) The DC to DC [switching circuit] converter  
2 of claim 32 wherein the control circuits are also responsive to  
3 rapid decreases in the voltage across the common load to turn on  
4 the plurality of buck converter circuits, independent of the  
5 phase of the plurality of pulse width modulators.

1        41. (Amended) The DC to DC [switching circuit] converter  
2 of claim 32 wherein the control circuits are also responsive to  
3 rapid increases in the voltage across the common load to turn off  
4 the plurality of buck converter circuits, independent of the  
5 phase of the plurality of pulse width modulators.

1        42. (Amended) The DC to DC [switching circuit] converter  
2 of claim 32, wherein the plurality of pulse width modulators  
3 consist of a pair of pulse width modulators.

1        43. (Amended) The DC to DC [switching circuit] converter  
2 of claim 32 wherein the commanded output voltage is controllable  
3 through an input to the integrated circuit.

*C9*  
*Claim Subst*

1        44. (Amended) The DC to DC [switching circuit] converter

2 of claim 32 wherein the feedback circuit is in the single  
3 integrated circuit.

1        45. (Twice Amended) A [circuit in a] DC to DC converter

2 having a plurality of converter circuits operating into a common  
3 load, comprising:

4              a plurality of buck converter circuits operating into the  
5              common load, each buck converter circuit having an inductor for  
6              alternately conducting between first and second power supply  
7              terminals, and the second power supply terminal and the common  
8              load;

9              a plurality of pulse width modulators each controlling  
10             [power switching devices of] one of the plurality of buck  
11             converter circuits, the operation of the pulse width modulators  
12             being interleaved;

13             control circuits for adjusting a nominal duty cycle of the  
14             plurality of interleaved buck converter circuits, the control  
15             circuits also being responsive to the difference in current in  
16             the plurality of interleaved buck converter circuits to adjust  
17             the relative duty cycle of the plurality of buck converter  
18             circuits to balance the current therein;

19             the plurality of pulse width modulators and the control  
20             circuits being in a single integrated circuit.

1       46. (Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having first and second interleaved converter circuits operating  
4 into a common load, comprising:

5       first and second buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10      a first pulse width modulator controlling the [power  
11 switching devices of the] first buck converter circuit;

12      a second pulse width modulator controlling the [power  
13 switching devices of the] second buck converter circuit;

14      a feedback circuit responsive to the voltage across the  
15 common load;

16      control circuits for controlling the first and second pulse  
17 width modulators responsive to the feedback circuit;

18      the control circuits also being responsive to current  
19 measurements in [through] the first buck converter circuit and  
20 the second buck converter circuit for adjusting the relative duty  
21 cycle of the first and second pulse width modulators to balance  
22 the currents in the buck converter circuits;

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23       the first pulse width modulator, the second pulse width  
24   modulator, the feedback circuit and the control circuits being in  
25   a single integrated circuit.

1       47. (Amended) A DC to DC [switching circuit for  
2   controlling power switching devices in a DC to DC] converter  
3   having a plurality of converter circuits operating into a common  
4   load, comprising:

5       a plurality of buck converter circuits operating into the  
6   common load, each buck converter circuit having an inductor for  
7   alternately conducting between first and second power supply  
8   terminals, and the second power supply terminal and the common  
9   load;

10      a plurality of pulse width modulators driven by a common  
11   oscillator in an interleaved manner, each pulse width modulator  
12   controlling [power switching devices of] one of the plurality of  
13   **buck** converter circuits, whereby the operation of the buck  
14   converter circuits is interleaved;

15      a feedback circuit responsive to a voltage across the common  
16   load;

17      a voltage control circuit for controlling the plurality of  
18   pulse width modulators responsive to the feedback circuit and a  
19   commanded output voltage; and

20      a current balance control circuit responsive to the  
21   difference in current in the plurality of interleaved buck

22     converter circuits for controlling the pulse width modulators to  
23     balance the current in the plurality of interleaved buck  
24     converter circuits.

1       48. (Amended) A DC to DC [switching circuit for  
2     controlling power switching devices in a DC to DC] converter  
3     having a plurality of converter circuits operating into a common  
4     load, comprising:

5           a plurality of buck converter circuits operating into the  
6     common load, each buck converter circuit having an inductor for  
7     alternately conducting between first and second power supply  
8     terminals, and the second power supply terminal and the common  
9     load;

10          a plurality of pulse width modulators each controlling power  
11     switching devices of one of the plurality of interleaved buck  
12     converter circuits, the operation of the pulse width modulators  
13     and the buck converter circuits being interleaved;

14          a feedback circuit responsive to a voltage across the common  
15     load;

16          control circuits responsive to the feedback circuit and a  
17     commanded output voltage to control a nominal duty cycle of the  
18     plurality of buck converter circuits, the control circuits also  
19     being responsive to the difference in current in the plurality of  
20     interleaved buck converter circuits to adjust the [adjusting a]

21 relative duty cycle of the plurality of buck converter circuits  
22 to balance the current in the buck converter circuits.

1           49. (Amended) A [circuit for a] DC to DC converter having  
2 a plurality of converter circuits operating into a common load,  
3 comprising:

4           a plurality of buck converter circuits operating into the  
5 common load, each buck converter circuit having an inductor for  
6 alternately conducting between first and second power supply  
7 terminals, and the second power supply terminal and the common  
8 load;

9           a plurality of pulse width modulators each controlling  
10 [power switching devices of] one of the plurality of buck  
11 converter circuits, the pulse width modulators being driven by a  
12 common oscillator signal so that the operation of the pulse width  
13 modulators is interleaved;

14           control circuits for adjusting a nominal duty cycle of the  
15 plurality of interleaved buck converter circuits to control a  
16 voltage on the common load, and for responding to the difference  
17 in current in the plurality of interleaved buck converter  
18 circuits to adjust the [adjusting a] relative duty cycle of the  
19 plurality of buck converter circuits to balance the current in  
20 the buck converter circuits.

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C44*

1       50. (Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having first and second [interleaved] converter circuits  
4 operating into a common load, comprising:

5       first and second buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10      a first pulse width modulator controlling the [power  
11 switching devices of the] first buck converter circuit;

12      a second pulse width modulator controlling the [power  
13 switching devices of the] second buck converter circuit;

14      a feedback circuit responsive to the voltage across the  
15 common load;

16      control circuits for controlling the first and second pulse  
17 width modulators responsive to the feedback circuit;

18      the control circuits also being responsive to current  
19 measurements through the first buck converter circuit and the  
20 second buck converter circuit to adjust [for adjusting] the  
21 relative duty cycle of the first and second buck converter  
22 circuits.

1       51. (Amended) A DC to DC [switching circuit for]  
2 controlling power switching devices in a DC to DC] converter  
3 [having a plurality of buck converter circuits operating into a  
4 common load,] comprising:

5       a plurality of buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10      a plurality of pulse width modulators driven by a common  
11 oscillator in an interleaved manner, each pulse width modulator  
12 controlling [power switching devices of] one of the plurality of  
13 buck converter circuits, whereby the operation of the buck  
14 converter circuits is interleaved;

15      a feedback circuit responsive to a voltage on [across] the  
16 common output [load];

17      a voltage control circuit for controlling the plurality of  
18 pulse width modulators responsive to the feedback circuit and a  
19 commanded output voltage; and

20      a current balance control circuit for controlling the pulse  
21 width modulators responsive to a difference in current in the  
22 inductors of the plurality of interleaved buck converter circuits  
23 to balance the current in the plurality of interleaved buck  
24 converter circuits;

25       the plurality of pulse width modulators and the control  
26   circuits being in a single integrated circuit.

1           52. (Amended) A DC to DC [switching circuit for  
2   controlling power switching devices in a DC to DC] converter  
3   having a plurality of [buck] converter circuits operating into a  
4   common load, comprising:

5           a plurality of buck converter circuits operating into the  
6   common load, each buck converter circuit having an inductor for  
7   alternately conducting between first and second power supply  
8   terminals, and the second power supply terminal and the common  
9   load;

10          a plurality of pulse width modulators each controlling power  
11   switching devices of one of the plurality of buck converter  
12   circuits, the operation of the pulse width modulators and the  
13   buck converter circuits being interleaved;

14          a feedback circuit responsive to a voltage across the common  
15   load;

16          control circuits being responsive to the feedback circuit  
17   and a commanded output voltage to control a nominal duty cycle of  
18   the plurality of buck converter circuits, the control circuits  
19   also being responsive to the difference in currents in the  
20   plurality of interleaved buck converter circuits to adjust the  
21   [u]adjusting a] relative duty cycle of the plurality of buck

22 converter circuits to balance the current in the buck converter  
23 circuits;

24 the plurality of pulse width modulators and the control  
25 circuits being in a single integrated circuit.

C 22  
Circuits

1 53. (Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having first and second [interleaved buck] converter circuits  
4 operating into a common load, comprising:

5 first and second buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10 a first pulse width modulator controlling the [power  
11 switching devices of the] first buck converter circuit;

12 a second pulse width modulator controlling the [power  
13 switching devices of the] second buck converter circuit;

14 a feedback circuit responsive to the voltage across the  
15 common load;

16 control circuits for controlling the first and second pulse  
17 width modulators responsive to the feedback circuit;

18 the control circuits also being responsive to current  
19 measurements in [through] the first buck converter circuit and  
20 the second buck converter circuit to adjust [for adjusting] the

21 relative duty cycle of the first and second buck converter  
22 circuits;  
23 the first pulse width modulator, the second pulse width  
24 modulator, the feedback circuit and the control circuits being in  
25 a single integrated circuit.

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C18*

1 54. (Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter  
3 having a plurality of [buck] converter circuits operating into a  
4 common load, comprising:  
5 a plurality of buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;  
10 a plurality of pulse width modulators driven by a common  
11 oscillator in an interleaved manner, each pulse width modulator  
12 controlling [power switching devices of] one of the plurality of  
13 buck converter circuits, whereby the operation of the buck  
14 converter circuits is interleaved;  
15 a feedback circuit responsive to a voltage across the common  
16 load;  
17 a voltage control circuit for controlling the plurality of  
18 pulse width modulators responsive to the feedback circuit and a  
19 commanded output voltage; and

20        a current balance control circuit for controlling the pulse  
21    width modulators to balance the current in the plurality of  
22    interleaved buck converter circuits responsive to the difference  
23    in current in the plurality of interleaved buck converter  
24    circuits.

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C-2  
C-3

1        55. (Amended) A DC to DC [switching] circuit for  
2    controlling power switching devices in a DC to DC] converter  
3    having a plurality of [buck] converter circuits operating into a  
4    common load, comprising:

5            a plurality of buck converter circuits operating into the  
6    common load, each buck converter circuit having an inductor for  
7    alternately conducting between first and second power supply  
8    terminals, and the second power supply terminal and the common  
9    load;

10          a plurality of pulse width modulators each controlling power  
11    switching devices of one of the plurality of interleaved buck  
12    converter circuits, the operation of the pulse width modulators  
13    and the buck converter circuits being interleaved;

14          a feedback circuit responsive to a voltage across the common  
15    load;

16          control circuits responsive to the feedback circuit and a  
17    commanded output voltage to control a nominal duty cycle of the  
18    plurality of buck converter circuits, the control circuits also  
19    adjusting a relative duty cycle of the plurality of buck

20 converter circuits to balance the current in the buck converter  
21 circuits responsive to the difference in current in the plurality  
22 of interleaved buck converter circuits.

1        56. (Amended) A [circuit for a] DC to DC converter having  
2 a plurality of [buck] converter circuits operating into a common  
3 load, comprising:

4        a plurality of buck converter circuits operating into the  
5 common load, each buck converter circuit having an inductor for  
6 alternately conducting between first and second power supply  
7 terminals, and the second power supply terminal and the common  
8 load;

9        a plurality of pulse width modulators each controlling  
10 [power switching devices of] one of the plurality of buck  
11 converter circuits, the pulse width modulators being driven by a  
12 common oscillator signal so that the operation of the pulse width  
13 modulators is interleaved;

14        control circuits for adjusting a nominal duty cycle of the  
15 plurality of interleaved buck converter circuits to control a  
16 voltage on the common load, and for adjusting a relative duty  
17 cycle of the plurality of buck converter circuits to balance the  
18 current in the buck converter circuits.

1        57. (Amended) A DC to DC [switching circuit for  
2 controlling power switching devices in a DC to DC] converter

3 having first and second [interleaved] buck converter circuits  
4 operating into a common load, comprising:

5 first and second buck converter circuits operating into the  
6 common load, each buck converter circuit having an inductor for  
7 alternately conducting between first and second power supply  
8 terminals, and the second power supply terminal and the common  
9 load;

10 a first pulse width modulator controlling the [power  
11 switching devices of the] first buck converter circuit;

12 a second pulse width modulator controlling the [power  
13 switching devices of the] second buck converter circuit;

14 a feedback circuit responsive to the voltage across the  
15 common load;

16 control circuits for controlling the first and second pulse  
17 width modulators responsive to the feedback circuit;

18 the control circuits also being responsive to current  
19 measurements in [through] the first buck converter circuit and  
20 the second buck converter circuit to adjust [for adjusting] the  
21 relative duty cycle of the first and second buck converter  
22 circuits.

1 58. (New) A DC to DC converter having a plurality of  
2 converter circuits for operating into a common load, comprising:  
3 a plurality of buck converter circuits operating into the  
4 common load, each buck converter circuit having an inductor for

5       alternately conducting between first and second power supply  
6       terminals, and the second power supply terminal and the common  
7       load;

8       a plurality of pulse width modulators driven by a common  
9       oscillator in an interleaved manner, each pulse width modulator  
10      controlling one of the plurality of buck converter circuits,  
11      whereby the operation of the buck converter circuits is  
12      interleaved;

13      a feedback circuit responsive to a voltage across the common  
14      output;

15      a voltage control circuit controlling the plurality of pulse  
16      width modulators responsive to the feedback circuit and a .  
17      commanded output voltage,

18      the plurality of pulse width modulators and the control  
19      circuits being in a single integrated circuit.

1  
2       59. (New) The DC to DC converter of claim 58 further  
3       comprising the common oscillator, the common oscillator also  
4       being in the single integrated circuit.

1  
2       60. (New) A DC to DC converter having a plurality of  
3       converter circuits operating into a common load, comprising:  
4       a plurality of buck converter circuits operating into the  
5       common load, each buck converter circuit having an inductor for  
6       alternately conducting between first and second power supply

6     terminals, and the second power supply terminal and the common  
7     load;

8         a plurality of pulse width modulators each controlling one  
9         of the plurality of buck converter circuits, the operation of the  
10         pulse width modulators and the buck converter circuits being  
11         interleaved;

12         a feedback circuit responsive to a voltage across the common  
13         load;

14         control circuits responsive to the feedback circuit and a  
15         commanded output voltage to control a nominal duty cycle of the  
16         plurality of buck converter circuits;

17         the plurality of pulse width modulators and the control  
18         circuits being in a single integrated circuit.

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Con'd  
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3*  
1     61. (New) The DC to DC converter of claim 58 further  
comprising the common oscillator, the common oscillator also  
being in the single integrated circuit.

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6*  
1     62. (New) A DC to DC converter comprising:  
first and second buck converter circuits operating into a  
common load, each buck converter circuit having an inductor for  
alternately conducting between first and second power supply  
terminals, and the second power supply terminal and the common  
load;

7       first and second pulse width modulators driven by a common  
8       oscillator in an interleaved manner, each pulse width modulator  
9       controlling a respective one of the first and second buck  
10      converter circuits, whereby the operation of the buck converter  
11      circuits is interleaved;

12      a feedback circuit responsive to a voltage across the common  
13      output;

14      a voltage control circuit controlling the first and second  
15      pulse width modulators responsive to the feedback circuit and a  
16      commanded output voltage;

17      the plurality of pulse width modulators and the control  
18      circuits being in a single integrated circuit.

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Cont'd  
Sub E10*  
63. (New) The DC to DC converter of claim 62 further  
comprising the common oscillator, the common oscillator also  
being in the single integrated circuit.

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D11*  
64. (New) A DC to DC converter comprising:  
first and second buck converter circuits operating into a  
common load, each buck converter circuit having an inductor for  
alternately conducting between first and second power supply  
terminals, and the second power supply terminal and the common  
load;

7       first and second pulse width modulators each controlling a  
8       respective one of the buck converter circuits, the operation of

9       the pulse width modulators and the buck converter circuits being  
10      interleaved;

11      a feedback circuit responsive to a voltage across the common  
12      load;

13      control circuits responsive to the feedback circuit and a  
14      commanded output voltage to control a nominal duty cycle of the  
15      plurality of buck converter circuits;

16      the plurality of pulse width modulators and the control  
17      circuits being in a single integrated circuit.

*C18  
Concil  
Sub E2D*  
65.    (New)   The DC to DC converter of claim 58 further  
comprising the common oscillator, the common oscillator also  
3      being in the single integrated circuit.